

US Army Corps of Engineers

Screening-Level Assessment of Projects with Respect to Sea Level Change



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USACE Responses to Climate Change Program

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EXECUTIVE SUMMARY

This report contains a summary of the US Army Corps of Engineers (USACE) initial screening-level assessment of the vulnerability of projects with respect sea level change. This is the first phase of a series of progressively more detailed screening assessments that will be completed before embarking on detailed assessments of the most vulnerable projects and those with the highest consequences. The screening level assessments were completed by USACE district staff using a web-based tool that interfaces with USACE geospatial databases. The comprehensive evaluation with respect to sea level (CESL) web tool also relies on information developed by other agencies, including the Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA) and the US Geological Survey (USGS). This report contains a detailed description of the development of CESL, the process used to collect the initial vulnerability assessment (IVA) data, and the results of the screening. Of the 5545 projects initially considered by CESL due to proximity to the coastline (within 40 miles of a tidally influenced body of water), 1431 were prescreened as potentially impacted by sea level change and were evaluated in the initial screening assessment. About one-third of these projects (487) were identified as being vulnerable to changing sea levels, and thus require examination in more detail in the next phase of the screening. The vulnerable projects were ranked and sorted resulting in 25 Very High, 69 High, 188 Medium, and 205 Low priority projects. The CESL tool used in USACE screening-level analyses can be made available to others who wish to perform similar coastal vulnerability assessments. This technical transfer has already begun with the transfer of the technology to Army staff for Installations, Environment, and Energy in 2015. By developing, testing, and making this toolkit available to others, USACE is well-aligned with the recommendations of the White House State, Local, and Tribal Leaders Task Force released in November 2014.

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1 INTRODUCTION

Climate change is among the major challenges of the 21st century facing the US Army Corps of Engineers (USACE), and can impact all areas of our missions and operations. Our climate preparedness and resilience policies [USACE, 2011a, 2014a] require us to integrate climate change adaptation planning and actions into USACE missions, operations, programs, and projects, using the best available and actionable climate science and climate change information at the appropriate level of analysis, and to consider climate change impacts when undertaking long-term planning, setting priorities, and making decisions. Since the issuance of *Executive Order 13514* [2009], and continuing with the President's Climate Action Plan [*Executive Office of the President*, 2013] and *Executive Order 13653* [2013], USACE has been a leader in collaborating with other agencies to integrate and translate climate science into actionable information for decision makers, develop technical guidance to address climate change impacts and adaptation, and develop tools to support adaptation decision-making. This report demonstrates USACE leadership through completion of a nationwide screening-level assessment of the vulnerability of our existing projects to the effects of changing sea levels.

1.1 BACKGROUND

Global sea levels vary over time and regionally, and have been the focus of intense interest by the U.S. federal agencies [e.g. *National Oceanic and Atmospheric Administration (NOAA)*, 2012; *National Research Council (NRC)*, 2012; *Melillo et al.*, 2014]. The Intergovernmental Panel on Climate Change (IPCC), particularly working groups 1 (Physical Science) and 2 (Impacts and Adaptation), have also expended considerable effort researching changing sea levels. Local relative sea level (LRSL) changes are a combination of global sea level and dynamic land changes such as subsidence or glacial rebound. Changes in LRSL directly impact coastal communities and important economic and ecological resources, as well as indirectly impact inland areas through supply chain and other economic interconnections.

The USACE requirement to include future conditions resulting from changing sea levels was first established through a 1986 guidance letter which addressed the historic rate of sea level [Eiker, 1986]. By 2000, Engineer Regulation (ER) 1105-2-100 [USACE, 2000] required that planners consider sensitivity to historic and high rate sea level change (SLC) as defined by the NRC [1987]. Internal and external analyses performed after Hurricane Katrina [*American Society of Civil Engineers (ASCE)*, 2006a, 2006b; *Interagency Performance Evaluation Taskforce (IPET)*, 2008; *Woolley and Shabman*, 2008] identified the need to incorporate new and changing information into the project planning, design, construction, operation, and maintenance phases of our civil works projects. As a result of these findings, the USACE published policy and guidance to establish a consistent nationwide datum [USACE, 2009a, 2010] and initiated the Comprehensive Evaluation of Project Datums (CEPD). The CEPD program evaluated all USACE projects and corrected those projects that were

not accurately related to the current National Spatial Reference System (NSRS) and local water level and tidal datums.

For the same reason, USACE also updated its guidance on how to understand and adapt to SLC in Civil Works (CW) programs and projects beginning in 2009. Post-Katrina USACE policy and guidance [USACE, 2009b, 2011b, 2013a] require that all USACE CW projects within the extent of estimated tidal influence must evaluate their robustness against three scenarios of future SLC. These low, intermediate, and high scenarios are based on different assumptions about physical processes and causes without specific attributions of likelihood. USACE also published technical guidance [USACE, 2014b] on how to adapt our projects, both new and existing, to changing sea levels. This guidance uses a tiered approach with the level of effort commensurate with scale of decision and consequences. These policies and methods are implemented for all new projects, and provide a foundation to begin to understand the vulnerabilities of existing projects.

1.2 VULNERABILITY ASSESSMENTS

Vulnerability assessments are necessary to help guide adaptation planning and implementation so that USACE can successfully perform its missions, operations, programs, and projects in an increasingly dynamic environment. USACE has completed several activities in connection with addressing vulnerabilities to climate change. The first was a preliminary assessment of how climate could impact Federal water resources management, presented in USGS Circular 1331 [Brekke *et al.*, 2009], published jointly by USACE, Bureau of Reclamation, the USGS, and NOAA. This document is focused primarily on watershed changes but noted a number of impacts from changing sea levels and suggested that “planning and design studies should consider designs that are most appropriate for a range of possible future rates of rise.”

In 2011, the Council on Environmental Quality (CEQ) required each Federal agency to undertake a high-level analysis of vulnerability to help each agency identify priorities for future adaptation [CEQ, 2011a, 2011b]. Changing sea levels and associated waves, tides, and surges were identified as a potential source of vulnerability in the USACE high-level vulnerability assessment [USACE, 2012, 2013b]. One of six priority areas identified in the USACE high-level assessment [USACE, 2012] was to complete and refine our preliminary, screening-level assessments of vulnerability to climate change.

Since that time, USACE has been conducting nationwide screening-level assessments of the vulnerability of USACE missions, operations, programs, and projects to climate change [USACE, 2013b]. Due to differences in the availability of actionable science, two concurrent vulnerability assessments are being conducted: one for coastal projects at the project scale, and one at the watershed scale for inland projects. Both screening-level vulnerability assessments are conducted in phases so that the initial assessments can be refined over time, using a modular approach so new and updated information can replace initial information, and supported by district-accessible tools and visualizations. The assessments will be merged in the future to provide complete watershed-coastshed assessments.

1.3 CURRENT EFFORT

This report describes the screening-level Initial Vulnerability Assessment (IVA) of existing coastal projects, which is part of the Comprehensive Evaluation of Projects with Respect to Sea Level Change (CESL) program building on post-Katrina recommendations around land subsidence, tidal fluctuations, and sea level change. The purpose of the CESL project is to assess the potential vulnerability of projects to the effects of SLC over the next 100 years, determine which projects need more comprehensive assessment or evaluation to better understand vulnerability, and to begin to prioritize more detailed assessments that will support adaptation planning and implementation. The phased approach allows us to identify vulnerabilities and uncertainties in climate projections or in systems responses with the joint goals of beginning adaptation first where vulnerabilities are relatively higher but at the same time the probability of adverse or unintended consequences is lower, and move to detailed assessments for projects where consequences are higher or where the probability of adverse or unintended consequences is higher.

This report contains a summary of the CESL effort along with an analysis of the data collected from the CESL web tool. A detailed discussion on the development of CESL, the process used to collect data, and the results based on this input are included. Data used by CESL came from USACE and other federal agencies such as Federal Emergency Management Agency (FEMA), United States Geological Survey (USGS), the Census Bureau, and the National Oceanic and Atmospheric Administration (NOAA). The results section includes the findings based on user input and analysis with other data. Findings and lessons learned are included in the conclusions section.

2 OVERVIEW

Consistent with other USACE climate change adaptation efforts, the CESL IVA relies on a web-accessible geospatial tool built on the foundation of the existing USACE automated information system, CorpsMap. The CESL web tool and IVA described in this report were developed based on requirements developed by a small interdisciplinary team based on user feedback. The tool relies on local USACE district staff to input data based on their local knowledge and engineering judgment. The CESL process includes training and technical support for the district teams to build technical capacity and improve knowledge about future coastal conditions and climate impacts that are required for adaptation planning and implementation. The four major features of the resulting CESL web tool are: the geospatial component, including linkages to the Corps Project Notebook and its underlying Oracle database, CorpsMap; the sea level change calculator, which provides repeatable analytical results and allows for nationwide comparisons; the CESL visualization tool, which tracks progress and provide easy access to overall results; and an automated impacts analysis that serves as a review step and assists in prioritization.

2.1 PROJECT TEAM

A Project Delivery Team (PDT) was assembled to assist in developing the CESL requirements. The PDT members involved in the initial CESL requirements were from the Army Geospatial Center (AGC), Jacksonville District (SAJ), Portland District (NWP), the Institute for Water Resources (IWR), the Engineer Research and Development Center (ERDC), and the National Oceanic and

Atmospheric Administration (NOAA). Several other USACE district representatives were involved in reviewing and providing feedback on CESL during various stages of development. The PDT also included contracted support.

2.2 REQUIREMENTS DEVELOPMENT

Requirements that underlie the CESL tool were developed by USACE staffers familiar with the planning, engineering, operation, and maintenance of USACE coastal projects. The context of the requirements considered by the team was guided by USACE adaptation policy [*USACE*, 2011a, 2014a] and CEQ [*CEQ*, 2011a, 2011b]. Members of the requirements development team also had experience with USACE policy and guidance around sea level change, subsidence, datums and vertical control, and adaptation policy. The resulting initial user requirements of CESL include:

- Web-based tool requiring no additional software and based on existing USACE geospatial systems.
- Secure Common Access Card (CAC)-enabled entry.
- Defined user roles control access to various aspects of the tool.
- Encompass project information required to perform an initial vulnerability assessment.
- Streamline input through the use of automatic entry of digital project data so that users verify and correct data as necessary without having to develop for individual projects.
- Identify authorized purpose(s) of project.
- Check for datum compliance according to policy and guidance by USACE [2009b, 2010].
- Serve as a repository for datum and tidal information, supporting nationally consistent and repeatable analytical results.
- Support consistent nationwide screening and prioritization process.
- Provide visualization to assist in estimation of vulnerability and consequences and to track IVA completion.
- Capture initial high level information on exposure and consequences, including the identification of elevation threshold(s) at which project performance could be impacted (per ETL 1100-2-1) and ballpark consequences in terms of economic damages [*USACE*, 2014b].
- Classify vulnerabilities to assist in prioritization.
- Provide some idea of whether projects need to take LRSLC into consideration immediately or can take longer to address.
- Identify projects determined to be highly susceptible or vulnerable to LRSLC and capture information allowing districts to perform a more detailed assessment in a consistent manner.
- Generate custom reports and project summaries.
- Serve as a hazard communication tool for other Federal and state agencies and local stakeholders.
- Support follow-on more detailed analyses and future project planning.

Once the initial requirements were developed, the PDT began organizing them into various categories which formed the basis for the high level functionality and components of the CESL web tool. The preliminary development of the CESL web tool consisted of various tabs including a map interface, search and report functions, a vulnerability assessment function, a parameter weighting/assignment, administration functions, and a help section. Feedback from USACE districts and PDT members after the initial CESL tool development recommended that the vulnerability assessment portion be broken into two components: an initial vulnerability assessment; and a more

detailed impacts assessment. The main reason for this change was to simplify the amount of data collected so that we could more easily determine which projects are most vulnerable to SLC. Based on this initial recommendation, the web tool was revised and tested through a pilot project with several USACE districts. Feedback collected from the pilot resulted in adjustments to improve data entry, reporting process, visual displays, and overall functionality.

2.3 GEOSPATIAL DATABASE INTERFACE

The CESL web tool includes multiple geospatial features allowing users to view and verify project information, view SLC curves for gauges at or near project sites, enter data, view Extreme Water Level (EWL) information, and view projects on a map interface. The initial list of projects came from the USACE Corps Project Notebook (CPN), which is considered to be the most comprehensive list of USACE projects. CPN provides a point location for each project along with authorized purpose(s), business line, and project phase (e.g. planning, operating). However, gaps or duplications were known to exist in CPN, so the CESL process required careful review and addition, deletion, or correction as necessary of CPN data for coastal projects. Data from CEPD was used within CESL to ensure that projects were tied to the correct vertical datums. Some data used by CESL, such as tide gauge location and observations, datum relationships, mean sea level trends, and extreme water levels were obtained from NOAA's Center for Operational Oceanographic Products and Services [NOAA, 2013b]. Other data used by CESL included the FEMA flood hazard based on FEMA base flood elevation (BFE), the USGS coastal vulnerability index [e.g., *Thieler and Hammar-Klose*, 1999], and the county population and population density data collected by the Census Bureau [2010]. The CESL database is used to store project related information from these various data sources along with the data entered by the USACE district users. This database can be used within the CESL tool to generate reports and export data to be used by others. Data can be pulled directly into visualization programs such as Tableau and internal USACE geospatial applications.

2.4 SEA LEVEL CHANGE CALCULATOR

The need to provide repeatable analytical results when addressing LRS LC in the planning and design of USACE CW projects required the development of a simple, web-based tool to calculate these changes. The Sea Level Change Curve Calculator uses the methodology described by USACE [2013a]. The calculator is hosted on a publicly available web site¹ so that our partners and stakeholders have access to the same information that we are using to understand potential project vulnerability. It uses data from NOAA Center for Operational Oceanographic Products and Services (CO-OPS), whose mission it is to maintain and communicate tide gauge data. A companion tool allows users to reach approved long-term non-NOAA tide gauges from this same site [USACE, 2013c]. The calculator also provides the capability for users to compare USACE sea level scenarios to those presented in the [*NOAA Technical Report OAR CPO-1: Global Sea Level Rise Scenarios for the United States National Climate Assessment*](#) [NOAA, 2012], the National Research Council's (NRC) 2012 report, "[*Sea Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*](#)" [NRC, 2012] and the 2013 update of the report by the [*New York City Panel on Climate Change*](#)

¹ <http://www.corpsclimate.us/ccaceslcurves.cfm>

(NPCC) [2013]. The calculator functionality was incorporated into the CESL web tool and used in evaluating projects for IVA. Users enter an elevation threshold at which performance can be impacted for a specific project and can visualize it relative to the USACE SLC scenarios (low, intermediate, and high curves). The user can opt to add extreme water levels calculated using either the Kriebel method [Kriebel *et al.*, 2015] method or the NOAA generalized extreme value (GEV) output to the SLC curves to visualize potential extreme events that could impact the project (e.g., Figure 1). District users performing the IVA used this in determining the potential vulnerability of a project to SLC along with the extreme water levels. The version of the sea level calculator in the CESL tool at the time of the IVA uses either the Kriebel method or user-entered values for extreme water levels. After the IVA was completed, the CESL calculator was updated to include the NOAA GEV as well.

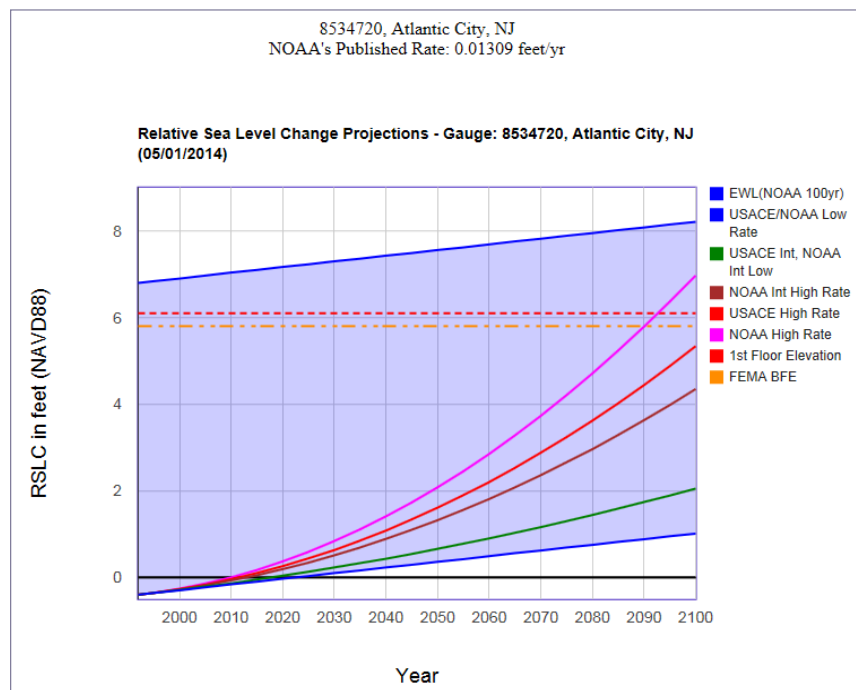


Figure 1: Example results from the Sea Level Change Calculator showing projected sea level changes when the NOAA GEV-computed 100yr return level water elevations are added to the USACE Low rate sea level curve. Also shown are the FEMA Base Flood Elevation.

2.5 VISUALIZATION AND MAPPING

The two primary components of visualization and mapping are the graphical presentation of the sea level change calculator and threshold elevation as described above, and an associated web tool to capture IVA progress. IVA progress visualization relies on commercial-off-the shelf software (Tableau) that is used in other USACE web visualizations, such as the watershed-based screening-level climate vulnerability assessment and the portal supporting the team updating drought contingency plans to incorporate climate change. This web-based Tableau visualization instance is map-based, allowing users to drill down to the MSC and district level and provides summary information on IVA status: not started, in progress, completed - not impacted, and completed –

impacted. (Figure 2, available to USACE staff only) A second tab provides additional information about the level of potential vulnerability identified in the IVA (low, moderate, high, very high) and additional drill-down to specific primary purposes (coastal storm damage reduction, commercial navigation, ecosystem restoration, flood damage reduction, hydropower, recreation, and water supply). It also provides direct access to information in the IVA through the use of a link in a pop-up window that appears when the user hovers on a particular project (Figure 3).

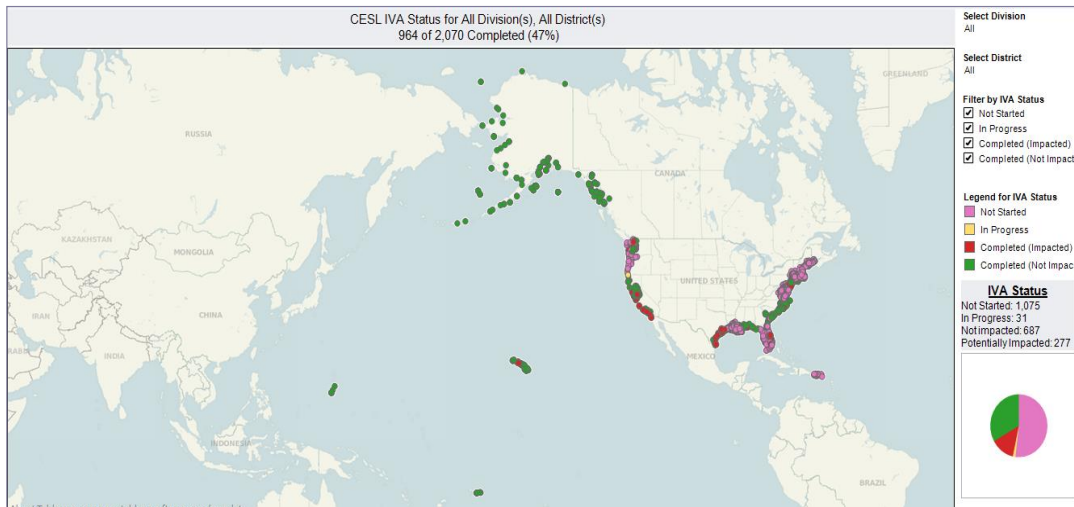


Figure 2: CESL Status Dashboard for 9 April 2014.

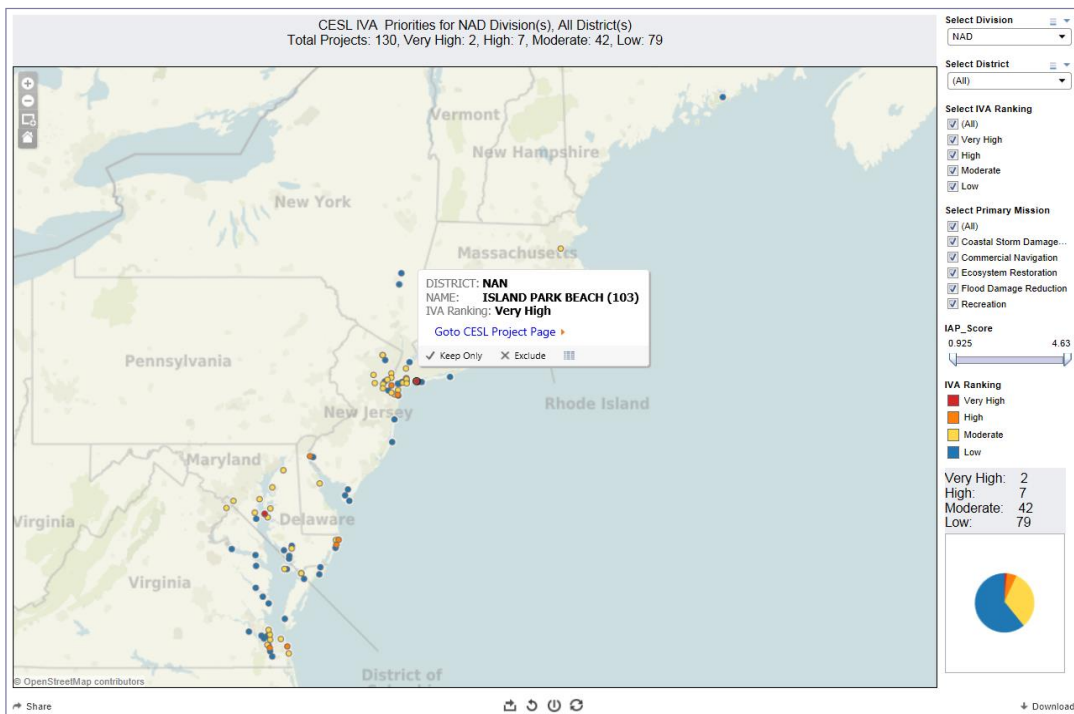


Figure 3: Tableau Dashboard showing the North Atlantic Division's IVA priority level and example of the pop-up window with link to a particular project.

3 PROCESS

PDT members developed a five-step process to be used in the assessment of potential SLC impacts on USACE coastal projects: prescreening, training, district data input, quality assurance and quality control, and scoring and ranking projects.

3.1 PRESCREENING

The CPN database does not contain an attribute to identify or quickly determine coastal projects or those that might be impacted by increases in SLC. CESL employed proximity analysis to determine those projects that would be considered “Potentially Impacted by SLC” and be required to undergo the IVA. The prescreening criteria selected all USACE projects within 40 miles of tidally influenced waters as determined by NOAA [NOAA, 2014]. The rationale for choosing this distance buffer was to minimize the chance of a Type II error (i.e., identify a project as not impacted when it is actually potentially impacted by SLC) by erring on the side of inclusion, while filtering out projects with minimal potential vulnerability. The prescreening included all projects in CPN within the selected proximity, including duplicate entries and projects in different phases. All projects identified in the prescreening as potentially impacted by SLC received an IVA. District staff made corrections to CPN throughout the IVA process, eventually decreasing the number of prescreened projects to 1431 from about 2400 (see, for example, the 9 April 2014 status shown in Figure 2, at which point 2070 prescreened projects were included).

3.2 TRAINING

In May 2013, a USACE Headquarters memo requested that each coastal district provide a POC and identify a small team of three to four staffers representing planning, engineering, operations and maintenance to complete an IVA for all coastal projects within their district. The PDT set up web permissions for the district POC and teams to access and enter data into the CESL tool. All users with a CAC can view data submitted into the tool, but only those with permissions may enter and edit data for their specific district’s projects. Once a district POC was identified, webinars presented in May and June of 2013 provided training on the purpose of IVA and specifics on entering data into the tool. Follow-up training was provided to individual district and division POCs on an as-needed basis. Following completion of the IVA in September 2014, training materials were developed to present the results to MSC POCs to obtain their input on any project classifications they felt should change. This training was provided by webinar in November and December 2014. All the training materials were posted to the CESL SharePoint site for future reference.

3.3 DISTRICT DATA INPUT

Data input begins with the selection of a project upon which to perform an assessment from the IVA tab of the CESL tool. Once in the IVA input page, the user reviews the project information, selects the primary mission area for the project, selects the appropriate compliant tidal gauge, enters the elevation threshold with its reference datum, source and description, and enters the FEMA base flood elevation (BFE) with its reference datum and date. The use of the FEMA BFE is not

intended to signify its use as a metric related to USACE project design or evaluation, but rather to familiarize users with obtaining external data and with reading FEMA products. CESL then displays the elevation threshold plotted with the SLC curves along with a table of the estimated extreme water levels. If project-related values are available from recent models that better describe the extreme water levels for this area, these may be entered as well.

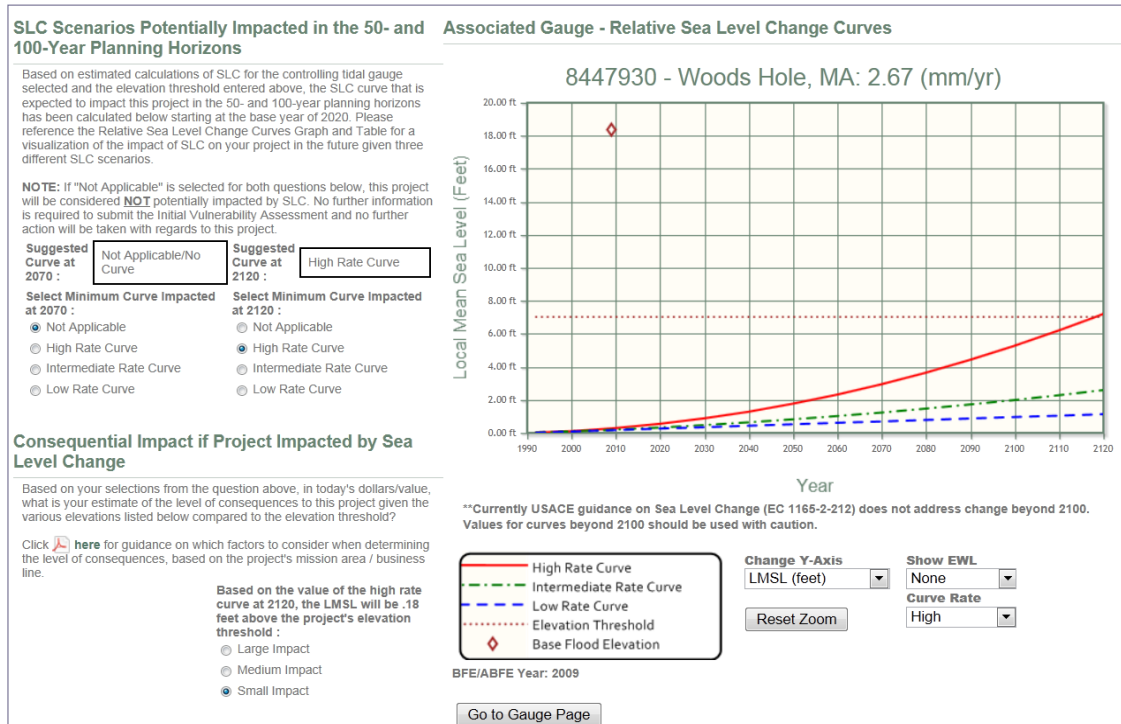


Figure 4: Example IVA Input for 50 and 100 year Planning Horizons (no estimated extreme water level).

Based on the intersection of the elevation threshold and SLC curves, and taking into consideration the extreme water level of an appropriate return interval, the user was asked to determine the impact of SLC on the project at 50 and 100 years (Figures 4 and 5). To provide consistency across districts in the IVA process, 2020 was used as the start year for the 50- (2070) and 100- (2120) year planning horizons. The user was also required to enter the project's local sponsor (if known), upload a map of the project (if available), enter a suggested priority for a more detailed study along with an explanation, and add additional comments if desired. After entering the required information, the user submits the data, the data entered is verified, and the project is classified in CESL as "Completed" or "Completed (Not Impacted by Sea Level Change)" as appropriate. A project classified as "Completed" means that the project is impacted by sea level change within the 50- or 100-yr planning horizon.

3.5 QA/QC OF IVA DATA

After each district completed the IVA for all their projects, the input was reviewed and scanned by the PDT leads for potential inconsistencies to ensure data quality and the resultant priorities. One part of the review involved searching through the database to identify projects with elevation threshold descriptions such as “crest of levee”, “top of floodwall”, or “top of structure,” and flagging these for review. These projects are potentially using an elevation threshold that is too high (i.e., not conservative). The database was also searched to identify and flag large differences between FEMA’s BFE and the estimated EWL 100-yr value, not to signify that these differences are meaningful in the context of USACE project design or evaluation, but rather to test the functionality of the flagging routine and to provide users with an opportunity to review whether this data from an external source was entered correctly. Information from several projects for each district was pulled and used to create a summary PowerPoint file. This PowerPoint file along with the list of projects, including flagged projects, was sent to each district POC for review and clarification. If necessary, the district POC went back into the CESL IVA and made changes and/or additions to the project information and resubmitted for review.

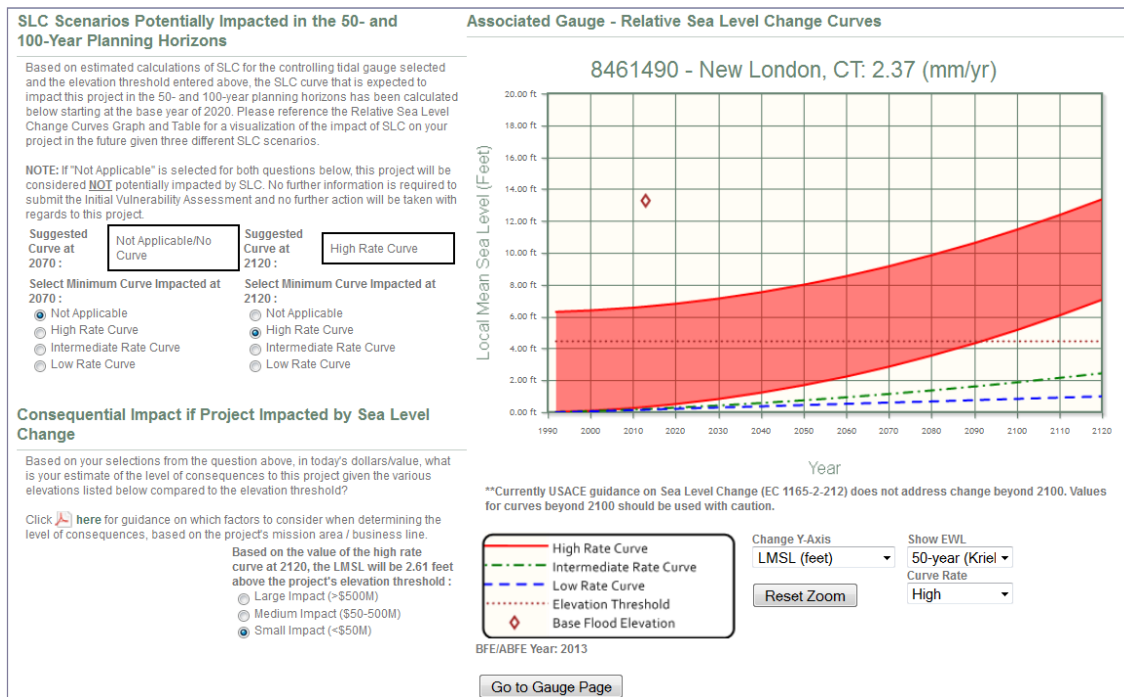


Figure 5: Example IVA Input for 50 and 100 year Planning Horizons (with extreme water level).

3.6 SCORING AND RANKING OF PROJECTS

Following submittal of district input data, each project was given two scores. The first score was based on the data entered in IVA and was used as the primary score in determining the priority of projects for a more detailed analysis. The IVA score was based on the following values (Figure 6 shows criteria used to develop these numbers, including weights used in the scoring):

- Average time until intersection of elevation threshold with High/Intermediate rate curves
- Average time until intersection of elevation with High/Intermediate rate curves with extreme water level (100 year return period)
- Consequential impact within 50-year planning horizon
- Consequential impact within 100-year planning horizon consequential impact
- District-suggested priority for more detailed study

Initial Vulnerability Assessment									
Parameter Boundaries									
Average Number of Years Until Intersect High / Intermediate Rate Curves:	Rank 1 >=	100	> Rank 2 >=	75	> Rank 3 >=	50	> Rank 4 >=	25	> Rank 5
50-year Planning Horizon Consequential Impact:	0 <= Rank 1 <	2	<= Rank 2 <	3	<= Rank 3 <	5	<= Rank 4 <	6	< Rank 5
100-year Planning Horizon Consequential Impact:	0 <= Rank 1 <	2	<= Rank 2 <	3	<= Rank 3 <	5	<= Rank 4 <	6	< Rank 5
Parameter Weights									
Average Time Until Intersect High/Intermediate Rate Curves : 10 %									
Average Time Until Intersect High/Intermediate Rate Curves with Extreme Water Level : 10 %									
50-year Planning Horizon Consequential Impact : 20 %									
100-year Planning Horizon Consequential Impact : 10 %									
Suggested Priority for More Detailed Study : 50 %									

Figure 6: Criteria used to develop IVA score based on data input.

A second score, the Parameters Analysis Score (PAS), was developed automatically within CESL and used as a secondary score to help prioritize projects for a more detailed analysis. The PAS was based solely on the following parameters:

- CEPD compliance
- County population
- FEMA flood hazard
- MSL trend from NOAA gauge
- Population density collected by the Census Bureau [2010]
- Project phase
- USGS Coastal Vulnerability Index (CVI) [Thieler and Hammar-Klose, 1999]

The PAS parameters were scored on a scale of 1-5, with 1 being low and 5 being high. Figure 7 from the Parameters Tab in the CESL web tool provides specific details on the weights and scoring used in the project rankings.

Parameter Analysis												
Parameter Boundaries												
CEPD Compliance :					NO =		5		YES =		1	
County Population :					0 <= Rank 1 <		250000		<= Rank 2 <		650000	
					<= Rank 3 <		1000000		<= Rank 4 <		3000000	
					<= Rank 5							
MSL Trend (mm/yr) :					Rank 1 <		.5		<= Rank 2 <		1.5	
					<= Rank 3 <		2.5		<= Rank 4 <		3.5	
					<= Rank 5							
County Population Density :					0 <= Rank 1 <		300		<= Rank 2 <		850	
					<= Rank 3 <		1500		<= Rank 4 <		3250	
					<= Rank 5							
USGS CVI :					CVI of 1 =		1		CVI of 2 =		2	
					CVI of 3 =		4		CVI of 4 =		5	
Project Phase Rank Associations												
Reconnaissance Study : 4												
Recreation Study : 4												
Feasibility Study : 5												
Preconstruction, Engineering & Design Study : 4												
Authorized Project : 3												
Constructed Project : 1												
Project Turned Over to Sponsor : 1												
Parameter Weights												
Enter whole numbers between 0 - 100 below for each parameter. The total of all fields must equal 100%. These values represent percentages that will be applied to each parameter to help determine the ultimate Phase 2 rank.												
CEPD Compliance : 5%												
County Population : 15%												
FEMA Flood Risk : 20%												
MSL Trend : 20%												
Population Density : 15%												
Project Phase : 5%												
USGS CVI : 20%												

Figure 7: Criteria used to develop Parameter Analysis Score

The IVA score and the PAS were combined to derive an Impacts Assessment Prioritization Score. The combined score is used to rank the projects' need for a more detailed assessment. Within CESL, scores greater than or equal to 4 are considered "Very High". Scores that are greater than or equal to 3 and less than 4 are considered "High". Scores that are greater than or equal to 2 and less than 3 are considered "Medium". Scores that are less than 2 are considered "Low."

The IVA score was given a greater weight than the PAS in combining the two scores because the user has far more knowledge about the project that can be derived from the supplemental parameters that rely on a single point based on the project's location. Determining the weights to apply to the IVA score and the PAS required an examination of how changes in the contribution of each score impacted the overall score and how this score compared to the users suggested priority. The goal of the sensitivity analysis was to be sure the combined score for each project did not overlook any highly vulnerable projects.

The sensitivity analysis was performed using an Excel spreadsheet. Graphs were produced to show the number of projects classified as Very High, High, Medium, and Low categories while the % weight of IVA score decreased in 10% increments from 100%, and the corresponding PAS weight increased in 10% increments from 0. An example is provided in Figure 8. The resulting classifications for each 10% change was reviewed and compared with the user's suggested priority score to ensure that user-identified high vulnerability projects were classified as either Very High or High. The results showed that combining the scores with the IVA score weighted 80% and the Parameter Analysis score weighted at 20% provides the optimum classifications. In a few cases, projects having a user-suggested classification as High were classified as Medium using the weighted scoring. Following case-by-case discussions with the users, these projects are expected to retain their Medium ranking.

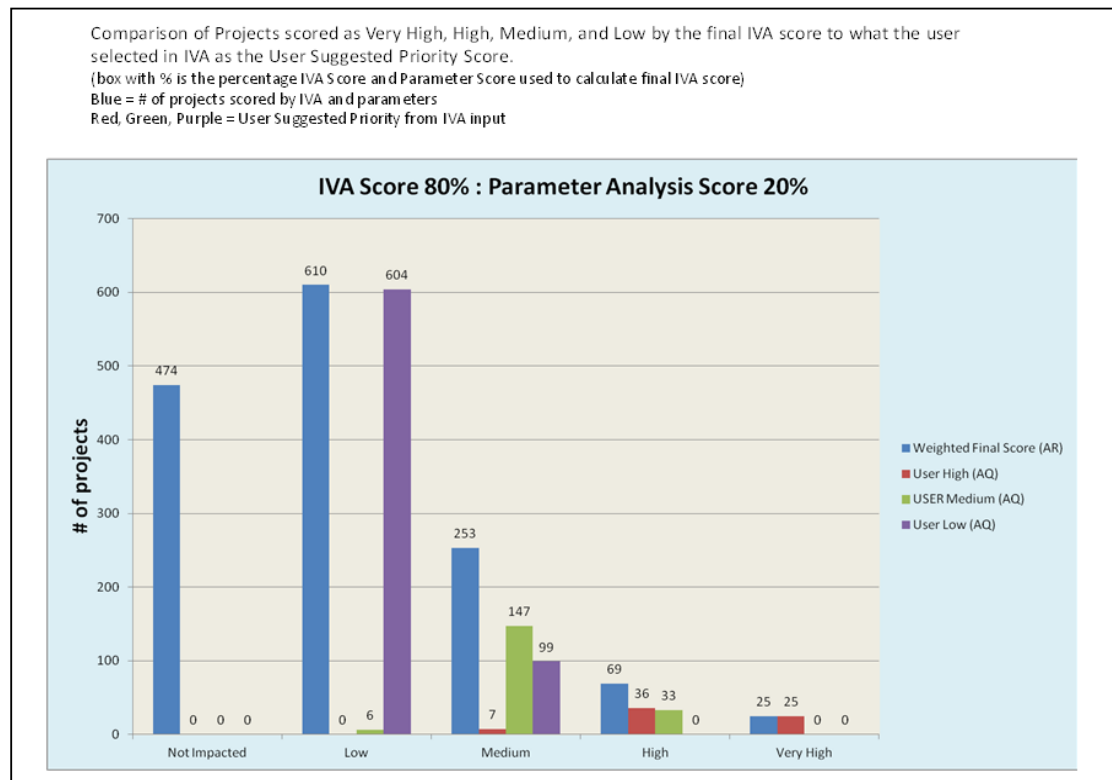


Figure 8: Example of sensitivity analysis for weighted scores

4 RESULTS

Of the 5545 projects brought into CESL from CPN, 1431 were prescreened as potentially impacted by sea level change (within 40 miles of a tidally influenced body of water). These 1431 projects were evaluated using the IVA. About two-thirds of these, or 944 projects, were identified as not vulnerable to SLC. About one-third of the projects (487) were considered to be vulnerable to SLC and thus require examination in more detail (Figure 9). Based on the combined 80/20 weighted IVA-PAS scoring, the 487 vulnerable projects were ranked and sorted resulting in 25 Very High, 69 High, 188 Medium, and 205 Low priority projects (Figure 10).

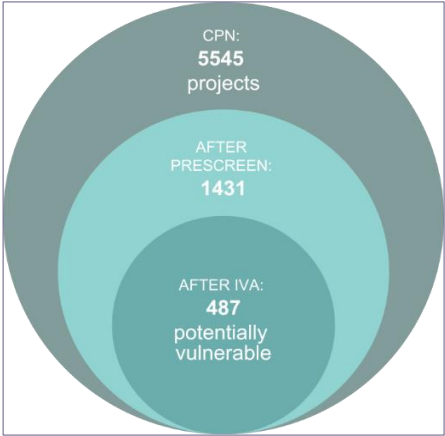


Figure 9: Number of projects considered in phases of the IVA.

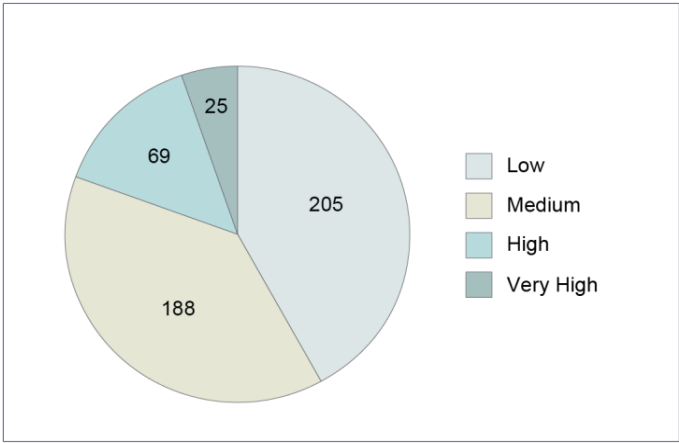


Figure 10: Graph of IVA Project Rankings.

5 NEXT STEPS

During development of the CESL tool and performance of the IVA, the PDT was engaged in concurrent development of the follow-on steps. These include an expansion of the IVA to collect more detailed information necessary to affirm IVA ranking and support a component-level vulnerability assessment, the expansion of the CESL tool for use in project planning to support SMART planning [USACE, 2014c], and pilot tests of the next level of detailed assessment.

5.1 INTERMEDIATE DETAILED ASSESSMENT

Based on the scoring of the 487 vulnerable projects, those with scores in the Very High and High classification require more detailed vulnerability assessments performed beginning in 2015 to refine our knowledge about their SLC vulnerability. The next level of assessment developed is the Intermediate Detailed Assessment (IDA), which collects feature-level data (individual structures and components) for each project. Information entered into IDA includes: survey data within the project area; identification of hydrodynamic models used for the project; information on project features and structures; wave and surge data for the project area; information about the project environment (geomorphology, habitat types and endangered species, conversion, adaptability); federal agencies with projects in and around the project area; and specific project documents. Project information collected during this phase will support a re-evaluation of IVA classification to guide the next step of streamlined vulnerability assessment. The IDA will also help identify what data may be lacking and need to be collected for each project.

5.2 CESL PLANNING TOOL

The CESL tool was developed to assess the vulnerability of existing projects in accordance with requirements for Federal agencies to undertake analyses of vulnerability to help each agency identify priorities for future adaptation [e.g., CEQ, 2011a, 2011b; Executive Order, 13653, 2013]. The capabilities of the CESL tool also support SMART planning [USACE, 2014c] by providing information that supports a better understanding of risks and consequences in the project area. In response to early feedback, alterations are being made to better assist planners as they consider the potential impacts of SLC during planning of new projects. These changes will help the user to visualize and document these potential impacts in accordance with USACE planning requirements.

5.3 STREAMLINED ASSESSMENTS

Following the IDA, the ranked projects will receive a streamlined assessment of different classes of projects (e.g., navigation structures, beach renourishment, and coastal ecosystem restoration projects). The streamlined assessment process is currently being piloted at the Stamford Hurricane Barrier [O'Brien *et al.*, in prep]. Lessons learned from this process will then be incorporated in the strategy to deploy streamlined assessments where appropriate nationally. Finally, the most complex and detailed projects likely require very detailed assessments, similar in scale to those conducted by Donoghue *et al.*, [2013]; Chadwick *et al.*, [2014]; and Li *et al.*, [2012].

6 CONCLUSIONS

The USACE conducted a screening-level analysis of the vulnerability of our coastal projects to climate change. In doing so, our geospatial databases were clarified, resulting in 1431 projects potentially impacted by sea level. About a third of the coastal projects were classified as being vulnerable to changing sea levels now or in the future. Of these, about 100 projects were classified as having high or very high vulnerability. The results of this screening level analysis are providing a foundation for USACE to continue a program of progressively more detailed screening assessments before embarking on detailed assessments of the most vulnerable projects and those with the highest consequences. This approach is consistent with a DoD policy report [*Strategic Environmental Research and Development Program (SERDP)*, 2013] prepared after the USACE screening assessment had begun.

The process included district staff feedback in developing the CESL tool, conducting the IVA, and developing the next steps. The feedback improved the tool and also helped to build ownership in the results. Over 35 district staff from 20 districts participated in the analysis along with the PDT. This level of participation certainly supports improved professional and technical competence at the district level with respect to sea level change. This is an important factor in mainstreaming climate change adaptation as called for in USACE climate preparedness and resilience policies [*USACE*, 2011a, 2014a].

Using the 40 mile buffer for the initial screening of projects produced a large number of projects that were beyond tidal influence and marked as N/A in the CESL tool. Because of the large number of projects that were evaluated during the screening phase, we feel confident that no projects that might be vulnerable were missed. Of the 944 projects identified as not impacted by SLC after IVA input, some may have to be reexamined if SLC rates and trends increase beyond the current projections. The data for these projects is stored in the CESL database, making re-evaluation in the future a relatively simple matter. Similarly, the projects considered to be impacted by SLC that scored in the medium and low categories may have to be reviewed if future projections indicate an increase in the rate of sea level change.

Finally, the CESL tool used in USACE screening-level analyses can be made available to others who wish to perform similar coastal vulnerability assessments. This technical transfer has already begun, with the transfer of the technology to Army staff for Installations, Environment, and Energy in 2015. Other users are encouraged to work with the contractors to evaluate the necessary modifications to suit their own particular purposes. By developing, testing, and making this toolkit available to others, USACE is well-aligned with the recommendations of the White House State, Local, and Tribal Leaders Task Force [*CEQ*, 2014].

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